



## I-95 Corridor Coalition

# I-95 Corridor Coalition Vehicle Probe Project: Validation of TomTom Data

Report for Pennsylvania (#9)  
PA-3, PA-23 and US-30



*September 2016*

# I-95 CORRIDOR COALITION VEHICLE PROBE PROJECT VALIDATION OF TOMTOM DATA SEPTEMBER 2016

*Report for Pennsylvania (#9)  
PA-3, PA-23 and US-30*

*Prepared for:*

I-95 Corridor Coalition

*Sponsored by:*

I-95 Corridor Coalition

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*September 2016*

# Evaluation Results for the State of Pennsylvania

## Executive Summary

The data from the Vehicle Probe Project is validated using Bluetooth™ Traffic Monitoring (BTM) technology on a near monthly basis. The validation of arterial data is similar to that of freeway data, however the following should be noted. The boundaries of the speed bins used for arterials are different than those used for freeways to accommodate the lower speeds on this type of corridor.

BTMs sensors were deployed at the beginning and ending points of 15 different segments along the PA-3, PA-23 and US-30 corridors. A summary the corridor characteristics follows:

Roadway	# of Lanes per Direction	Average Signal Density	Average Annual Daily Traffic	Speed Limit
PA-3	2 - 3	4 per mile	28,660	35 to 40 mph
PA-23	1 - 2	2 per mile	10,610	30 to 35 mph
US-30	2 - 3	5 per mile	23,200	25 to 40 mph

The Bluetooth sensor deployment covers the range from Providence Rd to State Rd along PA-3, Spring Mill Rd to US-1/ City Ave along PA-23 and Waterloo Rd to US-1/ City Ave along US-30. Travel time data was collected for both directions along each arterial, between April 20 and May 5, 2016. Due to data quality considerations, four segments were dropped from final validation resulting in 11 bidirectional and 3 directional segments for analysis. The dataset collected represents approximately 931 hours of observations along 14 arterial segments, totaling approximately 19 bidirectional and five directional miles. The total number of effective five-minute travel time samples observed was 11,177.

ES Table 1, below summarizes the results of the comparison between the BTM reference data and the TomTom data for arterial segments during the above noted time period. As shown, the average absolute speed error (AASE) was within specification in all speed bins. The Speed Error Bias (SEB) was also within specifications for all speed bins. Although the data are compared to these specifications, caution should be used when using probe data on arterial roadways. Other factors including signal density and traffic volume should be considered.

ES Table 1 – Maryland Evaluation Summary for Arterial						
Speed Bin	Average Absolute Speed Error (<10mph)		Speed Error Bias (<5mph)		Number of 5 Minute Samples	Hours of Data Collection
	Comparison with SEM Band	Comparison with Mean	Comparison with SEM Band	Comparison with Mean		
0-15 MPH	3.76	6.06	3.76	6.02	1086	91
15-25 MPH	3.28	6.05	3.18	5.67	5221	435
25-35 MPH	1.52	4.50	0.96	2.36	3442	287
>35 MPH	1.15	5.14	-0.20	-0.12	1428	119
All Speeds	2.51	5.46	2.12	3.94	11177	931

Based upon data collected from April 20, 2016 through May 5, 2016 across 43 miles of roadway.

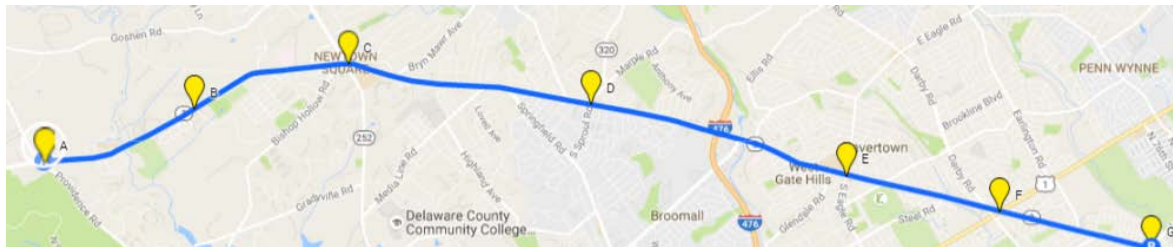
## Data Collection

Travel time samples were collected along 14 arterial segments with the assistance of Pennsylvania Department of Transportation (PennDOT) personnel. Arterial segments studied were located on the PA-3 corridor from Providence Rd to State Rd, on PA-23 corridor from Spring Mill Rd to US-1/ City Ave and on US-30 corridor from Waterloo Rd to US-1/ City. Travel time data was collected for both directions along PA-3, PA-23 and US-30 corridors between April 20 and May 5, 2016. Segment locations were chosen with a high-likelihood of observing recurrent and non-recurrent congestion during peak and off-peak periods.

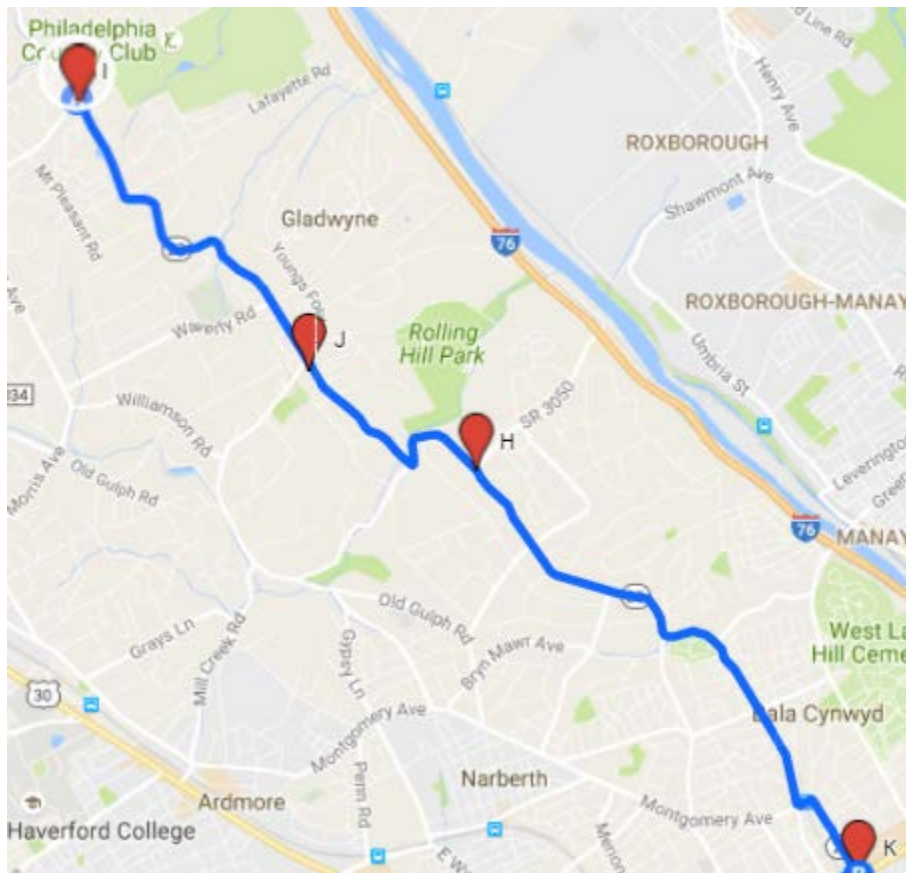
Figure 1, 2 and 3 present an overview snapshot of the placement of sensors for the collection of data on the PA-3, PA-23 and US-30 corridors in Pennsylvania, respectively.

A summary the corridor characteristics for these roadways follows:

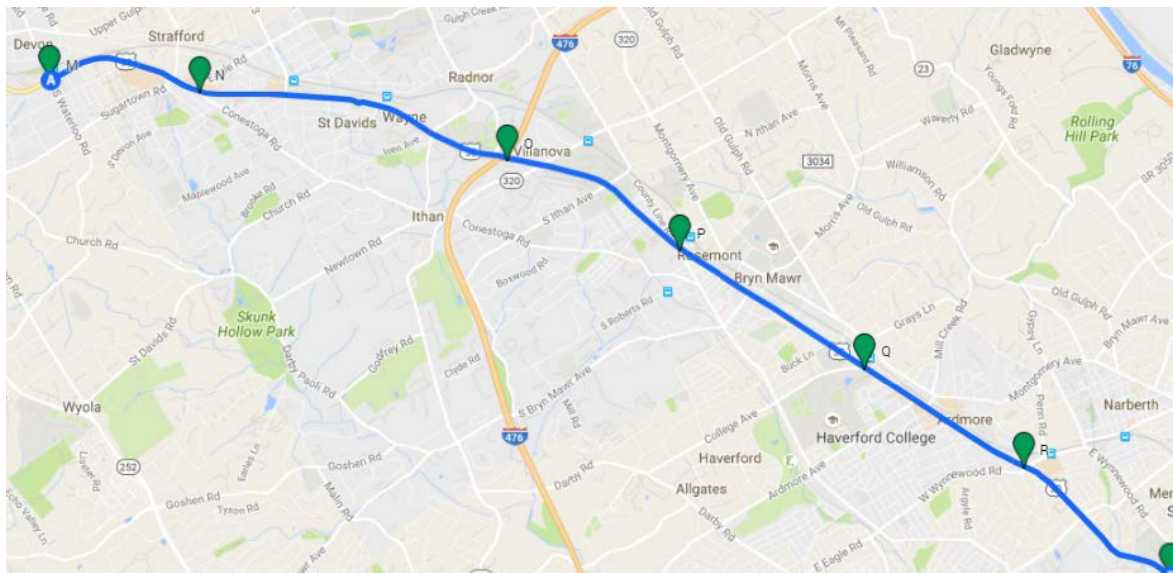
Roadway	# of Lanes per Direction	Average Signal Density	Average Annual Daily Traffic	Speed Limit
PA-3	2 - 3	4 per mile	28,660	35 to 40 mph
PA-23	1 - 2	2 per mile	10,610	30 to 35 mph
US-30	2 - 3	5 per mile	23,200	25 to 40 mph



**Figure 1** — Locations of all segments selected on PA-3 for analysis in Pennsylvania



**Figure 2** — Locations of all segments selected on PA-23 for analysis in Pennsylvania



**Figure 3** — Locations of all segments selected on US-30 for analysis in Pennsylvania

Table 1 presents the data collection segments from Pennsylvania. As a whole, these segments cover a total length of 19 bidirectional and 5 directional miles. Data collection segments are comprised of one or more Traffic Message Channel (TMC) base segments, such that total length of the data collection segment is one mile long or greater for arterials. When appropriate, consecutive TMC segments are combined to form a data collection segment longer than one mile. The results of validation performed on the 11 bidirectional and 3 directional arterial segments are included in this report. Table 1 contains summary information on each data collection segment including the latitude/longitude coordinates of the locations at which the Bluetooth sensors were deployed along PA-3, PA-23 and US-30 in Pennsylvania as well as an active map link to view the data collection segment in detail. Click on the map link to see a detailed map for the respective data collection segment. It should be noted that the configuration of the test segments is often such that the endpoint of one segment coincides with the start point of the next segment, so that one Bluetooth sensor covers both data collection segments.

Table 1 also provides data on the precise length of the TMCs comprising the test segment as compared to the measured length between Bluetooth<sup>TM</sup> Traffic Monitoring (BTM) sensors placed on the roadway. An algorithm was developed and documented in a separate report<sup>1</sup> as part of the initial VPP project and is being used for the validation of all vendors in VPPII. Details of the algorithm used to estimate equivalent path travel times based on TomTom data feeds for individual data collection segments are provided in this separate report. This algorithm finds an equivalent TomTom travel time (and therefore travel speed) corresponding to each sample BTM travel time observation on the test segment of interest.

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<sup>1</sup> Ali Haghani, Masoud Hamedi, Kaveh Farokhi Sadabadi, Estimation of Travel Times for Multiple TMC Segments, prepared for I-95 Corridor Coalition, February 2010 ([link](#))

**Table 1**  
**Segments selected for validation in Pennsylvania**

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		Length % Diff
	Highway Direction	State County	Starting at Ending at	Begin End	Number Length	Begin Lat/Lon End Lat/Lon		
<b>Arterial</b>								All Lengths in Miles
A1 <a href="#">PA09-0001</a>	PA-3 Eastbound	Pennsylvania Delaware	Providence Rd Alice Grim Blvd/Campus Blvd	103P15516 103P15516	1 2.52	39.9746 -75.4502 39.9811 -75.4251	1.42 -43.64%	
A2 <a href="#">PA09-0002</a>	PA-3 Eastbound	Pennsylvania Delaware	Alice Grim Blvd/Campus Blvd PA-252/N Newtown Street Rd	103P15516 103P05401	2 2.77	39.9811 -75.4251 39.9867 -75.4008	1.37 -50.62%	
A3 <a href="#">PA09-0003</a>	PA-3 Eastbound	Pennsylvania Delaware	PA-252/N Newtown Street Rd PA-320/N Sproul Rd	103P16968 103P05403	3 2.14	39.9867 -75.4008 39.9818 -75.3611	2.17 1.62%	
A4 <a href="#">PA09-0004</a>	PA-3 Eastbound	Pennsylvania Delaware	PA-320/N Sproul Rd Eagle Rd	103P05404 103P05405	2 2.29	39.9818 -75.3611 39.9730 -75.3196	2.28 -0.3%	
A5 <a href="#">PA09-0005</a>	PA-3 Eastbound	Pennsylvania Delaware	Eagle Rd US-1/E Township Line Rd	103P05406 103P05406	1 1.36	39.9730 -75.3196 39.9685 -75.2946	1.36 -0.25%	
A6 <a href="#">PA09-0006</a>	PA-3 Eastbound	Pennsylvania Delaware	US-1/E Township Line Rd State Rd	103P06964 103P06964	1 1.33	39.9685 -75.2946 39.9640 -75.2701	1.33 0.21%	
A7 <a href="#">PA09-0007</a>	PA-3 Westbound	Pennsylvania Delaware	N State Rd US-1/E Township Line Rd	103n05406 103n05406	1 1.32	39.9640 -75.2701 39.9686 -75.2943	1.33 0.76%	
A8 <a href="#">PA09-0008</a>	PA-3 Westbound	Pennsylvania Delaware	US-1/E Township Line Rd Eagle Rd	103n05406 103n05405	2 1.38	39.9686 -75.2943 39.9731 -75.3196	1.36 -1.25%	
A9 <a href="#">PA09-0009</a>	PA-3 Westbound	Pennsylvania Delaware	Eagle Rd PA-320/N Sproul Rd	103n05404 103n05404	2 2.29	39.9731 -75.3196 39.9819 -75.3611	2.28 -0.30%	
A10 <a href="#">PA09-0010</a>	PA-3 Westbound	Pennsylvania Delaware	PA-320/N Sproul Rd PA-252/N Newtown Street Rd	103n05403 103n05401	4 2.16	39.9819 -75.3611 39.9868 -75.4012	2.18 0.89%	



**Table 1 (Cont'd)**  
**Segments selected for validation in Pennsylvania**

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		Length % Diff
	Highway Direction	State County	Starting at Ending at	Begin End	Number Length	Begin Lat/Lon End Lat/Lon		
<b>Arterial</b>								All Lengths in Miles
A11 <a href="#">PA09-0011</a>	PA-3 Westbound	Pennsylvania Delaware	PA-252/N Newtown Street Rd Alice Grim Blvd/Campus Blvd	103n15516 103n06963	2 2.79	39.9868 -75.4012 39.9811 -75.4251	1.37 -50.94%	
A12 <a href="#">PA09-0012</a>	PA-3 Westbound	Pennsylvania Delaware	Alice Grim Blvd/Campus Blvd Providence Rd	103n06963 103n06963	1 2.53	39.9811 -75.4251 39.9747 -75.4503	1.42 -43.77%	
A13 <a href="#">PA09-0013</a>	PA-23 Eastbound	Pennsylvania Montgomery	Spring Mill Rd Youngsford Rd	103n04846 103n04846	1 1.96	40.0581 -75.3011 40.0391 -75.2793	1.96 0.13%	
A14 <a href="#">PA09-0014</a>	PA-23 Eastbound	Pennsylvania Montgomery	Youngsford Rd Hollow Rd	103n04845 103n04844	2 1.31	40.0391 -75.2793 40.031 -75.2631	1.29 -1.35%	
A15 <a href="#">PA09-0015</a>	PA-23 Eastbound	Pennsylvania Montgomery	Hollow Rd US-1/City Ave	103n04843 103n04840	4 3.12	40.031 -75.2631 40.0013 -75.2264	3.12 0.09%	
A16 <a href="#">PA09-0016</a>	PA-23 Westbound	Pennsylvania Montgomery	US-1/City Ave Hollow Rd	103P04841 103P04844	4 3.12	40.0013 -75.2264 40.031 -75.2631	3.12 0.09%	
A17 <a href="#">PA09-0017</a>	PA-23 Westbound	Pennsylvania Montgomery	Hollow Rd Youngsford Rd	103P04845 103P04846	2 1.31	40.031 -75.2631 40.0391 -75.2793	1.29 -1.35%	
A18 <a href="#">PA09-0018</a>	PA-23 Westbound	Pennsylvania Montgomery	Youngsford Rd Spring Mill Rd	103P04847 103P04847	1 1.96	40.0391 -75.2793 40.0581 -75.3011	1.96 0.13%	
A19 <a href="#">PA09-0019</a>	US-30 Eastbound	Pennsylvania Chester	Waterloo Rd Conestoga Rd	103n05517 103n05517	1 1.29	40.0458 -75.4234 40.0444 -75.4008	1.27 -1.64%	
A20 <a href="#">PA09-0020</a>	US-30 Eastbound	Pennsylvania Delaware	Conestoga Rd I-476	103n16952 103n05518	2 2.57	40.0444 -75.4008 40.0373 -75.3556	2.53 -1.69%	



**Table 1 (Cont'd)**  
**Segments selected for validation in Pennsylvania**

SEGMENT (Map Link)	DESCRIPTION			TMC CODES		Deployment		Length % Diff
	Highway Direction	State County	Starting at Ending at	Begin End	Number Length	Begin Lat/Lon End Lat/Lon		
<b>Arterial</b>								All Lengths in Miles
A21 <a href="#">PA09-0021</a>	US-30 Eastbound	Pennsylvania Delaware	I-476 County Line Rd	103n05518 103n07015	2 3.70	40.0373 -75.3556 40.0262 -75.3283	1.69 -54.35%	
A22 <a href="#">PA09-0022</a>	US-30 Eastbound	Pennsylvania Delaware	County Line Rd Railroad Ave	103n07015 103n07015	1 3.34	40.0262 -75.3283 40.0126 -75.3005	1.74 -47.91%	
A23 <a href="#">PA09-0023</a>	US-30 Eastbound	Pennsylvania Montgomery	Railroad Ave Wynnewood Rd	103n16795 103n05519	3 1.51	40.0126 -75.3005 40.0012 -75.2762	1.49 -1.10%	
A24 <a href="#">PA09-0024</a>	US-30 Eastbound	Pennsylvania Montgomery	Wynnewood Rd US-1/City Ave	103n05520 103n05520	1 1.51	40.0012 -75.2762 39.9883 -75.2540	1.54 1.75%	
A25 <a href="#">PA09-0025</a>	US-30 Westbound	Pennsylvania Montgomery	US-1/City Ave Wynnewood Rd	103P05519 103P05519	1 1.51	39.9883 -75.2540 40.0012 -75.2762	1.54 1.75%	
A26 <a href="#">PA09-0026</a>	US-30 Westbound	Pennsylvania Montgomery	Wynnewood Rd Railroad Ave	103P16794 103P07015	3 1.51	40.0012 -75.2762 40.0126 -75.3005	1.49 -1.10%	
A27 <a href="#">PA09-0027</a>	US-30 Westbound	Pennsylvania Delaware	Railroad Ave County Line Rd	103p05518 103p05518	1 3.30	40.0126 -75.3005 40.0262 -75.3283	1.74 -47.33%	
A28 <a href="#">PA09-0028</a>	US-30 Westbound	Pennsylvania Delaware	County Line Rd I-476	103P05518 103P05518	1 3.64	40.0262 -75.3283 40.0373 -75.3556	1.69 -53.35%	
A29 <a href="#">PA09-0029</a>	US-30 Westbound	Pennsylvania Delaware	I-476 Conestoga Rd	103P05518 103P05517	3 2.61	40.0373 -75.3556 40.0444 -75.4008	2.53 -2.95%	
A30 <a href="#">PA09-0030</a>	US-30 Westbound	Pennsylvania Chester	Conestoga Rd Waterloo Rd	103P05516 103P05516	1 1.29	40.0444 -75.4008 40.0458 -75.4234	1.26 -2.41%	

## ***Analysis of Arterial Results***

Table 2 summarizes the data quality measures obtained as a result of comparison between Bluetooth and all reported TomTom speeds. Specifications include the Average Absolute Speed Error (AASE) and the Speed Error Bias (SEB).

### Average Absolute Speed Error (AASE)

The AASE is defined as the mean absolute value of the difference between the mean speed reported from the VPP and the ground truth mean speed for a specified time period. The AASE is the primary accuracy metric. Based on the contract specifications, the speed data from the VPP shall have a maximum average absolute error of 10 miles per hour (MPH) in each of four speed ranges: 0-15 MPH, 15-25 MPH, 25-35 MPH, and > 35 MPH.

### Speed Error Bias (SEB)

The SEB is defined as the average speed error (not the absolute value) in each speed bin. SEB is a measure of whether the speed reported in the VPP consistently under or over estimates speed as compared to ground truth speed. Based on the contract specifications, the VPP data shall have a maximum SEB of +/- 5 MPH in each of speed ranges as defined above.

The results are presented as compared against the mean of the ground truth data as well as the 95<sup>th</sup> percent confidence interval for the mean, referred to as the Standard Error of the Mean (SEM) band. The SEM band takes into account any uncertainty in the ground truth speed as measured by BTM equipment due to limited samples and/or data variance. Contract specifications are assessed against the SEM band. (See the *Vehicle Probe Project: Data Use and Application Guide* for additional details on the validation process.) The AASE in the lower two speed bins have proven to be the critical specification (and most difficult) to attain. As shown, the average absolute speed error (AASE) was within specification for all the speed bins. The Speed Error Bias (SEB) was also within specifications for all speed bins.

**TABLE 2**  
**Data quality measures for arterial segments in Pennsylvania.**

SPEED BIN	Data Quality Measures for				No. of 5 Minute Samples	Hours of Data Collection
	1.96 SEM Band		Mean			
	SEB 5 mph (contract specifications)	AASE 10 mph	SEB	AASE		
0-15	3.76	3.76	6.02	6.06	1086	91
15-25	3.18	3.28	5.67	6.05	5221	435
25-35	0.96	1.52	2.36	4.50	3442	287
35+	-0.20	1.15	-0.12	5.14	1428	119

Table 3 shows the percentage of the time TomTom data falls within 5 mph of the SEM band and the mean for each speed bin for all arterial data segments in Pennsylvania.

**Table 3 Percent observations meeting data quality criteria for arterial segments in Pennsylvania**

SPEED BIN	Data Quality Measures for				No. of Obs.
	1.96 SEM Band		Mean		
	Percentage falling inside the band	Percentage falling within 5 mph of the band	Percentage equal to the mean	Percentage within 5 mph of the mean	
0-15	14%	73%	0%	48%	1086
15-25	30%	72%	0%	45%	5221
25-35	56%	90%	0%	65%	3442
35+	69%	91%	0%	55%	1428

Tables 4 and 5 present detailed data for individual TMC segments in Pennsylvania in a similar format as Tables 2 and 3, respectively. Note that for some segments and in some speed bins the comparison results may not be reliable due to small number of observations.

**Table 4**  
**Data quality measures for individual arterial validation segments in the state of Pennsylvania**

TMC	Standard TMC length	Bluetooth distance	SPEED BIN	Data Quality Measures for				No. of Obs.
				1.96 SEM Band		Mean		
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
PA09-0003	2.13	2.17	0-15	4.0	4.0	5.9	5.9	53
			15-25	6.4	6.4	9.3	9.3	245
			25-35	3.0	3.0	6.3	6.5	60
			35+	-0.9	0.9	-1.6	2.5	12
PA09-0004	2.28	2.28	0-15	5.2	5.2	6.3	6.3	46
			15-25	5.7	5.7	8.3	8.3	242
			25-35	2.7	2.9	5.6	6.0	82
			35+	-1.5	1.5	-4.0	4.0	6
PA09-0005	1.37	1.36	0-15	4.3	4.3	7.9	7.9	25
			15-25	1.3	1.4	3.2	3.6	599
			25-35	-1.7	1.7	-5.6	5.6	117
			35+	-7.3	7.3	-18.0	18.0	9
PA09-0006	1.33	1.33	0-15	5.8	5.8	8.2	8.2	25
			15-25	4.8	4.9	9.0	9.2	261
			25-35	1.2	1.4	4.1	4.9	342
			35+	-0.9	0.9	-3.8	3.8	14
PA09-0007	1.32	1.33	0-15	6.6	6.6	10.5	10.5	42
			15-25	3.0	3.1	6.4	6.7	420
			25-35	0.0	0.5	0.7	2.9	239
			35+	-3.1	3.1	-8.0	8.0	16
PA09-0008	1.38	1.36	0-15	2.9	2.9	4.5	4.7	141
			15-25	4.2	4.3	6.6	6.9	620
			25-35	0.2	1.2	0.8	4.5	39
			35+	-	-	-	-	-
PA09-0009	2.29	2.28	0-15	2.2	2.2	3.8	3.8	18
			15-25	3.8	3.8	6.8	6.8	156
			25-35	1.6	1.6	4.0	4.5	131
			35+	-1.4	1.4	-4.1	4.3	31
PA09-0010	2.17	2.18	0-15	3.9	3.9	5.8	5.8	35
			15-25	5.7	5.7	8.4	8.4	214
			25-35	3.0	3.0	6.2	6.4	79
			35+	-0.2	0.2	-1.6	3.0	12
PA09-0011	2.80	1.37	0-15	12.3	12.3	17.8	17.8	3
			15-25	8.4	8.4	14.9	14.9	62
			25-35	4.4	4.4	10.3	10.3	312
			35+	0.1	0.5	2.2	4.2	228
PA09-0012	2.80	1.42	0-15	-	-	-	-	-
			15-25	7.3	7.3	10.0	10.0	9
			25-35	6.6	6.6	11.7	11.8	119
			35+	0.2	1.0	0.6	5.1	996

\*Results in the specified row may not be reliable due to small number of observations

**Table 4 (Cont'd)**  
**Data quality measures for individual arterial validation segments in the state of Pennsylvania**

TMC	Standard TMC length	Bluetooth distance	SPEED BIN	Data Quality Measures for				No. of Obs.
				1.96 SEM Band		Mean		
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
PA09-0013	1.96	1.96	0-15	0.9	0.9	1.4	1.4	2
			15-25	2.5	2.7	3.8	4.2	53
			25-35	-0.1	0.6	-0.1	2.1	199
			35+	-4.6	4.6	-7.1	7.1	6
PA09-0014	1.31	1.31	0-15	1.7	1.7	2.1	2.2	31
			15-25	0.9	1.2	2.1	3.2	104
			25-35	-0.7	0.7	-2.1	2.5	152
			35+	-6.9	6.9	-9.9	9.9	1
PA09-0017	1.31	1.31	0-15	2.1	2.1	3.1	3.1	4
			15-25	1.7	1.7	3.0	3.7	37
			25-35	-0.7	0.8	-1.8	2.5	186
			35+	-4.9	4.9	-7.7	7.7	5
PA09-0018	1.96	1.96	0-15	0.4	0.4	1.2	1.2	1
			15-25	1.8	2.1	4.7	5.1	26
			25-35	0.2	0.5	0.7	2.2	209
			35+	-4.9	4.9	-6.6	6.6	2
PA09-0019	1.29	1.27	0-15	5.1	5.1	8.5	8.5	68
			15-25	3.1	3.2	5.7	6.1	249
			25-35	1.1	1.2	3.9	4.4	28
			35+	-	-	-	-	-
PA09-0020	2.58	2.53	0-15	5.4	5.4	8.2	8.2	40
			15-25	5.1	5.2	7.6	7.7	110
			25-35	0.0	0.8	0.7	3.1	11
			35+	-	-	-	-	-
PA09-0021	3.35	1.69	0-15	3.2	3.2	4.9	4.9	162
			15-25	1.3	1.6	2.8	3.7	401
			25-35	-1.0	1.0	-3.8	3.8	103
			35+	-6.9	6.9	-12.1	12.1	9
PA09-0022	3.35	1.74	0-15	2.8	2.8	6.6	6.6	38
			15-25	1.2	1.8	2.3	3.9	126
			25-35	-0.3	0.3	-3.5	3.5	8
			35+	-	-	-	-	-
PA09-0024	1.52	1.54	0-15	2.2	2.2	4.7	4.7	5
			15-25	2.9	3.0	5.4	5.9	191
			25-35	0.4	0.8	1.8	3.4	409
			35+	-2.0	2.0	-6.6	6.6	28
PA09-0025	1.52	1.54	0-15	-	-	-	-	-
			15-25	4.4	4.4	8.4	8.4	86
			25-35	0.5	0.6	2.2	3.0	483
			35+	-1.5	1.5	-5.5	5.5	46

\*Results in the specified row may not be reliable due to small number of observations

**Table 4 (Cont'd)**  
**Data quality measures for individual arterial validation segments in the state of Pennsylvania**

TMC	Standard TMC length	Bluetooth distance	SPEED BIN	Data Quality Measures for				No. of Obs.
				1.96 SEM Band		Mean		
				Speed Error Bias	Average Absolute Speed Error	Speed Error Bias	Average Absolute Speed Error	
PA09-0026	1.51	1.49	0-15	3.8	3.8	6.6	6.6	93
			15-25	1.5	1.5	3.7	3.9	86
			25-35	-0.8	0.8	-3.6	3.6	6
			35+	-	-	-	-	-
PA09-0027	3.28	1.74	0-15	1.7	1.7	5.0	5.4	13
			15-25	0.6	1.3	1.6	3.4	163
			25-35	-1.8	1.8	-4.2	4.2	20
			35+	-12.9	12.9	-15.3	15.3	2
PA09-0028	3.28	1.69	0-15	3.0	3.0	5.0	5.1	209
			15-25	1.6	1.7	3.7	4.1	400
			25-35	-0.8	0.8	-4.0	4.0	51
			35+	-11.9	11.9	-16.4	16.4	2
PA09-0029	2.64	2.53	0-15	7.4	7.4	11.1	11.1	7
			15-25	3.0	3.0	6.2	6.2	59
			25-35	0.0	0.0	2.3	2.3	4
			35+	-10.4	10.4	-15.6	15.6	1
PA09-0030	1.29	1.26	0-15	6.1	6.1	10.7	10.7	25
			15-25	3.4	3.4	6.2	6.4	302
			25-35	0.4	0.7	1.1	4.0	53
			35+	-1.2	1.2	-4.1	4.1	2

\*Results in the specified row may not be reliable due to small number of observations

**Table 5**  
**Observations meeting data quality criteria for individual arterial validation segments**  
**in the state of Pennsylvania**

TMC	SPEED BIN	Data Quality Measures for								No. of Obs.
		1.96 SEM Band				Mean				
		Speed Error Bias		Average Absolute Speed Error		Speed Error Bias		Average Absolute Speed Error		
		No. falling inside the band	% falling inside the band	No. falling within 5 mph of the band	% falling within 5 mph of the band	No. equal to the mean	% equal to the mean	No. within 5 mph of the mean	% within 5 mph of the mean	
PA09-0003	0-15	0.0	0%	24.0	45%	0.0	0%	21.0	40%	53
	15-25	1.0	0%	41.0	17%	0.0	0%	25.0	10%	245
	25-35	2.0	3%	24.0	40%	0.0	0%	17.0	28%	60
	35+	5.0	42%	10.0	83%	0.0	0%	10.0	83%	12
PA09-0004	0-15	0.0	0%	16.0	35%	0.0	0%	14.0	30%	46
	15-25	1.0	0%	49.0	20%	0.0	0%	41.0	17%	242
	25-35	2.0	2%	37.0	45%	0.0	0%	31.0	38%	82
	35+	0.0	0%	4.0	67%	0.0	0%	4.0	67%	6
PA09-0005	0-15	0.0	0%	5.0	20%	0.0	0%	4.0	16%	25
	15-25	84.0	14%	491.0	82%	0.0	0%	442.0	74%	599
	25-35	12.0	10%	73.0	62%	0.0	0%	52.0	44%	117
	35+	0.0	0%	0.0	0%	0.0	0%	0.0	0%	9
PA09-0006	0-15	0.0	0%	10.0	40%	0.0	0%	10.0	40%	25
	15-25	15.0	6%	69.0	26%	0.0	0%	49.0	19%	261
	25-35	37.0	11%	214.0	63%	0.0	0%	173.0	51%	342
	35+	1.0	7%	12.0	86%	0.0	0%	10.0	71%	14
PA09-0007	0-15	1.0	2%	10.0	24%	0.0	0%	7.0	17%	42
	15-25	30.0	7%	175.0	42%	0.0	0%	116.0	28%	420
	25-35	48.0	20%	230.0	96%	0.0	0%	221.0	92%	239
	35+	0.0	0%	2.0	13%	0.0	0%	0.0	0%	16
PA09-0008	0-15	11.0	8%	89.0	63%	0.0	0%	83.0	59%	141
	15-25	32.0	5%	287.0	46%	0.0	0%	244.0	39%	620
	25-35	5.0	13%	30.0	77%	0.0	0%	22.0	56%	39
	35+	-	-	-	-	-	-	-	-	-
PA09-0009	0-15	1.0	6%	15.0	83%	0.0	0%	14.0	78%	18
	15-25	2.0	1%	67.0	43%	0.0	0%	58.0	37%	156
	25-35	15.0	11%	92.0	70%	0.0	0%	80.0	61%	131
	35+	9.0	29%	24.0	77%	1.0	3%	23.0	74%	31
PA09-0010	0-15	0.0	0%	21.0	60%	0.0	0%	19.0	54%	35
	15-25	2.0	1%	53.0	25%	0.0	0%	43.0	20%	214
	25-35	4.0	5%	36.0	46%	0.0	0%	31.0	39%	79
	35+	1.0	8%	11.0	92%	0.0	0%	10.0	83%	12
PA09-0011	0-15	0.0	0%	0.0	0%	0.0	0%	0.0	0%	3
	15-25	0.0	0%	0.0	0%	0.0	0%	0.0	0%	62
	25-35	10.0	3%	62.0	20%	0.0	0%	28.0	9%	312
	35+	48.0	21%	179.0	79%	0.0	0%	138.0	61%	228
PA09-0012	0-15	-	-	-	-	-	-	-	-	-
	15-25	0.0	0%	0.0	0%	0.0	0%	0.0	0%	9
	25-35	4.0	3%	13.0	11%	0.0	0%	9.0	8%	119
	35+	247.0	25%	706.0	71%	0.0	0%	548.0	55%	996

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**Table 5 (Cont'd)**  
**Observations meeting data quality criteria for individual arterial validation segments**  
**in the state of Pennsylvania**

TMC	SPEED BIN	Data Quality Measures for								No. of Obs.
		1.96 SEM Band				Mean				
		Speed Error Bias		Average Absolute Speed Error		Speed Error Bias		Average Absolute Speed Error		
		No. falling inside the band	% falling inside the band	No. falling within 5 mph of the band	% falling within 5 mph of the band	No. equal to the mean	% equal to the mean	No. within 5 mph of the mean	% within 5 mph of the mean	
PA09-0013	0-15	0.0	0%	2.0	100%	0.0	0%	2.0	100%	2
	15-25	6.0	11%	34.0	64%	0.0	0%	22.0	42%	53
	25-35	40.0	20%	196.0	98%	0.0	0%	196.0	98%	199
	35+	0.0	0%	1.0	17%	0.0	0%	0.0	0%	6
PA09-0014	0-15	4.0	13%	29.0	94%	0.0	0%	29.0	94%	31
	15-25	7.0	7%	89.0	86%	0.0	0%	84.0	81%	104
	25-35	32.0	21%	136.0	89%	0.0	0%	130.0	86%	152
	35+	0.0	0%	0.0	0%	0.0	0%	0.0	0%	1
PA09-0017	0-15	0.0	0%	4.0	100%	0.0	0%	4.0	100%	4
	15-25	2.0	5%	31.0	84%	0.0	0%	28.0	76%	37
	25-35	42.0	23%	170.0	91%	0.0	0%	165.0	89%	186
	35+	0.0	0%	0.0	0%	0.0	0%	0.0	0%	5
PA09-0018	0-15	0.0	0%	1.0	100%	0.0	0%	1.0	100%	1
	15-25	2.0	8%	17.0	65%	0.0	0%	5.0	19%	26
	25-35	36.0	17%	209.0	100%	0.0	0%	209.0	100%	209
	35+	0.0	0%	0.0	0%	0.0	0%	0.0	0%	2
PA09-0019	0-15	2.0	3%	19.0	28%	0.0	0%	17.0	25%	68
	15-25	14.0	6%	132.0	53%	0.0	0%	118.0	47%	249
	25-35	4.0	14%	21.0	75%	0.0	0%	12.0	43%	28
	35+	-	-	-	-	-	-	-	-	-
PA09-0020	0-15	1.0	3%	14.0	35%	0.0	0%	10.0	25%	40
	15-25	2.0	2%	28.0	25%	0.0	0%	25.0	23%	110
	25-35	1.0	9%	11.0	100%	0.0	0%	11.0	100%	11
	35+	-	-	-	-	-	-	-	-	-
PA09-0021	0-15	0.0	0%	110.0	68%	0.0	0%	95.0	59%	162
	15-25	34.0	8%	317.0	79%	0.0	0%	287.0	72%	401
	25-35	23.0	22%	79.0	77%	0.0	0%	73.0	71%	103
	35+	0.0	0%	0.0	0%	0.0	0%	0.0	0%	9
PA09-0022	0-15	0.0	0%	19.0	50%	0.0	0%	14.0	37%	38
	15-25	12.0	10%	90.0	71%	0.0	0%	83.0	66%	126
	25-35	1.0	13%	7.0	88%	0.0	0%	7.0	88%	8
	35+	-	-	-	-	-	-	-	-	-
PA09-0024	0-15	1.0	20%	4.0	80%	0.0	0%	3.0	60%	5
	15-25	19.0	10%	84.0	44%	0.0	0%	81.0	42%	191
	25-35	69.0	17%	357.0	87%	0.0	0%	309.0	76%	409
	35+	0.0	0%	16.0	57%	0.0	0%	11.0	39%	28
PA09-0025	0-15	-	-	-	-	-	-	-	-	-
	15-25	2.0	2%	10.0	12%	0.0	0%	6.0	7%	86
	25-35	120.0	25%	439.0	91%	0.0	0%	384.0	80%	483
	35+	0.0	0%	35.0	76%	0.0	0%	27.0	59%	46

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**Table 5 (Cont'd)**  
**Observations meeting data quality criteria for individual arterial validation segments**  
**in the state of Pennsylvania**

TMC	SPEED BIN	Data Quality Measures for								No. of Obs.
		1.96 SEM Band				Mean				
		Speed Error Bias		Average Absolute Speed Error		Speed Error Bias		Average Absolute Speed Error		
		No. falling inside the band	% falling inside the band	No. falling within 5 mph of the band	% falling within 5 mph of the band	No. equal to the mean	% equal to the mean	No. within 5 mph of the mean	% within 5 mph of the mean	
PA09-0026	0-15	1.0	1%	39.0	42%	0.0	0%	32.0	34%	93
	15-25	6.0	7%	70.0	81%	0.0	0%	64.0	74%	86
	25-35	0.0	0%	5.0	83%	0.0	0%	4.0	67%	6
	35+	-	-	-	-	-	-	-	-	-
PA09-0027	0-15	2.0	15%	9.0	69%	0.0	0%	8.0	62%	13
	15-25	22.0	14%	131.0	80%	0.0	0%	118.0	72%	163
	25-35	4.0	20%	14.0	70%	0.0	0%	12.0	60%	20
	35+	0.0	0%	0.0	0%	0.0	0%	0.0	0%	2
PA09-0028	0-15	2.0	1%	138.0	66%	0.0	0%	125.0	60%	209
	15-25	41.0	10%	289.0	72%	0.0	0%	260.0	65%	400
	25-35	10.0	20%	37.0	73%	0.0	0%	31.0	61%	51
	35+	0.0	0%	0.0	0%	0.0	0%	0.0	0%	2
PA09-0029	0-15	0.0	0%	2.0	29%	0.0	0%	2.0	29%	7
	15-25	4.0	7%	23.0	39%	0.0	0%	18.0	31%	59
	25-35	1.0	25%	4.0	100%	0.0	0%	4.0	100%	4
	35+	0.0	0%	0.0	0%	0.0	0%	0.0	0%	1
PA09-0030	0-15	0.0	0%	5.0	20%	0.0	0%	3.0	12%	25
	15-25	30.0	10%	159.0	53%	1.0	0%	129.0	43%	302
	25-35	8.0	15%	45.0	85%	0.0	0%	33.0	62%	53
	35+	0.0	0%	2.0	100%	0.0	0%	2.0	100%	2

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